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Forensic implication of muscle level of nicotine in an adipocere body found in the sea

Hiroyuki Nishimura, Junichi Furumiya, Akinori Nakanishi, Yoshiaki Hashimoto

Department of Legal Medicine, Kochi Medical School, Kochi University, Kohasu, Oko-cho,

Nankoku City, Kochi 783-8505, Japan

Corresponding author: Hiroyuki Nishimura

Department of Legal Medicine,

Kochi Medical School, Kochi University,

Kohasu, Oko-cho, Nankoku City,

Kochi 783-8505, Japan

Tel.: +81 88 880 2419

fax: +81 88 880 2420

E-mail address: hnishimura@kochi-u.ac.jp (H. Nishimura).

Abstract

We reported previously that blood levels of nicotine in suicidal smokers tend to be significantly higher than those in non-suicidal smokers, and blood level of nicotine seems to be a useful criterion for discriminating suicide from other types of death. In this paper, we report nicotine and cotinine levels in various tissues of an adipocere body found in the sea. The cause of death was drowning, and the postmortem time interval was approximately 5 months at autopsy. His driver's license was concealed in his sock, which seemed to suggest that he committed to suicide. In toxicological analysis by gas chromatography, nicotine and cotinine in the femoral muscle were detected at concentrations of 213 and 488 ng/g, respectively, and these substances were also detected in the brain, liver and kidney. For evaluating the tissue levels of nicotine and cotinine in the adipocere body, we analyzed these levels in blood and various tissues of 13 autopsy cases of smokers. Nicotine and cotinine levels in blood were the most similar to those in skeletal muscle. Although the postmortem time interval, the formation process of adipocere and the environmental condition in water may affect nicotine and cotinine levels in the femoral muscle, the high muscle level of nicotine in the present case seem to implicate suicidal death.

Keywords: Toxicological analysis; Suicide; Smoker; Nicotine; Cotinine; Skeletal muscle

1. Introduction

We reported previously that nicotine levels in blood of suicidal smokers tend to be significantly higher than those of non-suicidal smokers [1, 2], and the analysis of blood nicotine in unusual deaths of smokers seems to be a useful criterion for discriminating suicide from other types of death. However, the criterion is not applied in an autopsy case in which blood cannot be obtained from the vessels.

Since there is little data on blood-alternate sample for analysis of nicotine and cotinine, we have analyzed nicotine and cotinine levels in blood and various tissues in human autopsy cases of smokers. In addition, we estimated blood levels of nicotine and cotinine from various tissue levels in an adipocere body which was diagnosed as drowning by suicide.

2. Case history

A 42-year-old man (175 cm tall and weighing 45 kg) with marked adipocere formation was found in the sea in early December. The postmortem time interval was estimated to be approximately 5 months at autopsy. No traumatic injuries were found. Blackish cloudy fluids in both thoracic cavities were observed (right: 700 ml, left: 350 ml). The brain, weighing 1 kg, was almost completely converted into adipocere, but other organs were not. Massive tobacco tar was observed on the surface of his teeth. His driver's license was concealed in his sock, which seemed to suggest that he committed to suicide. In toxicological analysis by gas chromatography, nicotine and cotinine derived from smoking were detected in the skeletal

muscle, brain, liver and kidney. Other drugs and poisons were not detected. Diatoms were detected in both lungs. The cause of death was diagnosed as drowning by suicide.

3. Toxicological analysis

3-1. Measurement of nicotine and cotinine

Quantitative analysis of nicotine and cotinine in biological specimens was performed by a gas chromatographic method as described previously [1].

3-2. Analysis of human autopsy cases

For estimating the blood levels of nicotine and cotinine from the tissue levels of the adipocere body, we analyzed nicotine and cotinine levels in blood and various tissues of 13 autopsy cases of smokers. The causes of death were death by fire in 8 cases, traumatic injury in 3 cases and drowning in 2 cases. The postmortem time intervals were 9 – 72 h (median: 24 h). At autopsy, blood samples were obtained from the aorta or femoral vein, and the skeletal muscle samples were obtained from the iliopsoas or thigh. Small pieces of the brain, liver and kidney were also collected.

4. Results

As shown in Table. 1, nicotine in the adipocere body was detected at concentrations of 54.3 – 379 ng/g, and cotinine was also detected at concentrations of 414 – 2650 ng/g.

The summarized data of nicotine and cotinine levels in various specimens of 13 autopsy cases are shown in Table 2. Correlation coefficients of nicotine and cotinine levels between blood and various tissues were as follows: 0.97 and 0.97 in the skeletal muscle, 0.96 and 0.92 in the brain, 0.78 and 0.94 in the liver, and 0.75 and 0.99 in the kidney. As shown in Table 3, the median concentration ratios of the skeletal muscle to blood were close to 1 in both nicotine and cotinine.

5. Discussion

Forensic toxicologists have explored alternative samples to blood, because they often encounter autopsy cases in which blood cannot be obtained from the vessels. Some researchers reported that drug level in skeletal muscle reflects that in blood [3-5], but others suggested that skeletal muscle is suitable only for qualitative analysis [6, 7]. To our knowledge, there is little literature about tissue distributions of nicotine and cotinine in human autopsy cases of smokers. The data of Urakawa et al. showed that there were no significant differences of nicotine and cotinine levels in the muscle of abdomen and thigh [5]. Therefore, we collected skeletal muscle from the iliopsoas or thigh for nicotine and cotinine analysis. In addition, Urakawa et al. reported that nicotine and cotinine levels in skeletal muscle of 10 autopsy cases were quite similar to those in blood [5]. Although our median ratio of nicotine level in skeletal muscle to blood tended to be a little higher than Urakawa et al. [5], our result was almost consistent with them. Therefore, skeletal muscle seems to be suitable as a

blood-alternate sample for quantitative analysis of nicotine and cotinine, when blood is not available.

We reported previously that blood levels of nicotine in suicidal smokers tend to be significantly higher than those in non-suicidal smokers [2], and blood level of nicotine seems to be a useful criterion for discriminating suicide from other types of death. Based on our results which obtained from 13 analytical cases, we estimated that blood levels of nicotine and cotinine from the muscle levels in the adipocere body case were 175 and 519 ng/ml, respectively, using median ratios of nicotine and cotinine levels in skeletal muscle to blood. These levels were considered to be extremely high levels in previous report about suicidal smokers [2], although the postmortem time interval, the formation process of adipocere and the environmental condition in water may affect nicotine and cotinine levels in the muscle. According to the police investigation, autopsy findings and nicotine analysis, we strongly considered that he committed suicide.

Conflict of interest: None.

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Table 1. Nicotine and cotinine levels in various tissues of an adipocere body

	Concentration (ng/g)			
	Femoral muscle	Brain	Liver	Kidney
Nicotine	213	54.3	379	235
Cotinine	488	414	2650	1070

Table 2. Nicotine and cotinine levels in various specimens of 13 autopsy cases

Case No.	Cause of death	PMI ^a (h)	Nicotine / Cotinine concentration (ng/ml or ng/g)				
			Blood	Skeletal muscle	Brain	Liver	Kidney
1	Death by fire	24	242 / 995	271 / 768	292 / 509	1530 / 5720	473 / 1100
2	Traumatic injury	9	57.2 / 127	69.9 / 93.7	108 / 57.6	333 / 386	122 / 89.3
3	Death by fire	22	41.3 / 174	47.0 / 105	73.0 / 105	116 / 856	92.5 / 160
4	Death by fire	18	5.86 / 144	32.1 / 220	28.1 / 116	137 / 1510	58.1 / 145
5	Death by fire	13	39.8 / 113	46.2 / 59.7	69.5 / 83.8	1060 / 1180	81.6 / 82.1
6	Death by fire	24	55.1 / 144	60.3 / 101	77.6 / 75.3	142 / 650	89.9 / 100
7	Death by fire	34	57.7 / 43.2	32.9 / 13.0	46.5 / 11.2	650 / 204	109 / 12.3
8	Death by fire	32	65.3 / 229	89.7 / 230	92.7 / 149	74.6 / 528	306 / 296
9	Traumatic injury	31	17.5 / 202	41.0 / 192	50.6 / 141	131 / 1310	158 / 157
10	Traumatic injury	20	29.3 / 418	27.3 / 436	14.1 / 424	111 / 2360	343 / 351
11	Death by fire	50	37.5 / 355	79.3 / 361	77.9 / 257	202 / 1260	106 / 370
12	Drowning	24	26.6 / 166	37.0 / 205	61.0 / 119	110 / 532	64.1 / 150
13	Drowning	72	106 / 400	130 / 375	139 / 237	500 / 1270	338 / 348

^aPostmortem time interval.

Table 3. Ratios of nicotine and cotinine levels in various tissues to those in blood

	Tissue / Blood Ratio			
	Median (Range)			
	Skeletal muscle	Brain	Liver	Kidney
Nicotine	1.22 (0.57 – 5.48)	1.75 (0.48 – 4.80)	5.39 (1.14 – 26.6)	2.41 (1.63 – 11.7)
Cotinine	0.94 (0.30 – 1.53)	0.65 (0.26 – 1.01)	4.72 (2.31 – 10.5)	0.87 (0.28 – 1.29)